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Research Article

Sensitisation, research and management for conservation within ESPOL University forests after the COVID-19 pandemic, Ecuador

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Abstract

Non sustainable land uses are disturbing natural habitats and wild animals' ecology worldwide. Nevertheless, the sensitisation of key actors combined with research and a consequent management can influence decision-making and improve animals' well-being. COVID-19 has influenced the number of interactions with wildlife in urban environments and the ESPOL Polytechnic University is a university campus that holds forested areas in Guayaquil, Ecuador. We implemented an environmental education course with an empathetic approach for the security guards of the university. We used questionnaires to evaluate their attitudes and knowledge on wildlife before and after the sensitisation course. In addition, we registered the incidences of native fauna resulting from the guards' collaborations and we designed management strategies according to the data gathered. The guards showed an improvement in their knowledge of the issues covered (n = 81–87; $\bar{X}$ = 163.4%) and an increased preference for wild and native fauna after the sensitisation course (n = 67; 151.6%). Furthermore, the collaborations of guards with the Biodiversity Unit of the university concerning animal-human interactions increased, as did the supporting actions towards the well-being of native animals. Moreover, the information about direct and indirect interactions with wildlife included reports on traces of large to medium animal activity and a record of illegal hunting of *Choloepus hoffmanni* for bushmeat consumption. Obtained data sustained adaptive management actions such as signalling and restrictions in use. We recommend educating key actors with an empathetic approach, developing critical skills and promoting collaborations to reduce human impacts in wild areas.

Key words: Awareness, citizen-science, empathy, environmental education, management, *Puma concolor*

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Introduction

To achieve conservation goals and ensure the sustainable use of the landscape, protected area management needs to consider natural values, key actors and land use (Dudley 2013; Angelici and Rossi 2020; Procko et al. 2022). ESPOL Polytechnic University, Campus Gustavo Galindo, comprises an urban area, agricultural land for scientific purposes and two main forested areas; Prosperina Protected Forest (BPP), which is connected to Cerro Blanco Reserve and the

Parcón area forest (Vera Morales et al. 2021). The area is not inhabited by native communities, but is frequented by students from ESPOL University and visitors from the highly-populated city of Guayaquil, primarily for recreational and educational purposes (Vera Morales et al. 2021). The landscape belongs to a regional hotspot for conservation, the hotspot of Darien-Chongón-West of Ecuador (designated due to its high endemic diversity and high degree of deforestation) (Myers et al. 2000). Both areas are daily visited by hikers and bikers' and contain stationary water systems (Parcón area also contains a lake) (Vera Morales et al. 2021). Water bodies and best-preserved forests are of great importance for fauna, animals using these areas to meet their biological needs (Dudley 2013; Procko et al. 2022). In fact, due to the seasonality of precipitations in dry tropical forests and the scarcity of available water during the dry season, water bodies play an important role in maintaining faunal populations (Western 1975; Beier et al. 1995; Quadros and Monteiro-Filho 2001). On the other hand, factors influencing the biodiversity can vary depending on the temporal and spatial scenario. The COVID-19 pandemic and lockdowns have resulted in a worldwide change in people's activities and, apparently, wildlife movements (Behera et al. 2022; Naseer et al. 2022). The reduced human presence in open environments could have increased wildlife mobility, extended their exploratory activities and consequently increased the number of sightings (Naseer et al. 2022). However, some authors believe that it also could be a by-product of having more people paying attention to nature globally (Montgomery et al. 2021).

Environmental education aims to develop awareness about nature, increase knowledge and promote positive attitudes that will influence protective behaviour and social norms (Monroe et al. 2008). To this end, charismatic species can play an important role in seeking public engagement and facilitating sensitisation on conservation issues (Monroe et al. 2008). At the same time, understanding the public's relationship with wildlife and conservation objectives can help establishing protection measures since most of the impacts generated in nature have an anthropogenic origin (Schultz 2000; Špur et al. 2017; Villalba-Briones et al. 2021). Through the communication of conservation science, environmental education activities are enriched and the perspective towards biodiversity protection is addressed, linking society to the natural environment (Schultz 2000; Bickford et al. 2012). The environmental education activity's approach is crucial for its success (Bickford et al. 2012; Singh and Rahman 2012; Špur et al. 2017). The motivational message and reasons to act are resources that must be included to seek a change of attitudes towards wildlife conservation (Schultz 2000; Špur et al. 2017). Additionally, empathy-promoting activities are valuable tools to encourage people to appreciate wild species and make decisions aligned with conservationism (Littledyke 2008; Berenguer 2010; Villalba-Briones et al. 2021). Biophilic attitudes can lead to critical thinking and result in actual conservation actions and care for the well-being of animals (Villalba-Briones et al. 2021).

Large animals, especially mammals, are usually the most appreciated animals for adults and children (Albert et al. 2018; Thompson and Rog 2019). At the same time, primates and large predators are charismatic species that attracts the public's attention (Albert et al. 2018; Bezanson and McNamara 2019). These species can also be considered as flagship species when they encourage more expansive conservation actions (Albert et al. 2018; Thompson and Rog 2019).

Management for conservation is needed to control impacts since human activities alter natural environments and can be detrimental for wildlife populations (Pickering 2010; Procko et al. 2022). Moreover, large predators are key species for ecosystem functioning, but suffer a decline in their populations due to anthropogenic factors (Ripple et al. 2014). Cougars are the second largest predator from South America and, on the Ecuadorian coast, the species is categorised as critically endangered (Tirira 2021). South American cougar subspecies are smaller than higher latitudinal subspecies and rely more on smaller prey (Iriarte et al. 1990). However, anthropogenic conflicts threatening their survival still exist due to depletion of natural prey, attacks on cattle, habitat degradation and retaliation from local communities (Ripple et al. 2014; Treves and Bruskotter 2014). In addition, social aspects and a perception of danger for humans frequently result in an active decline of carnivore populations (Treves and Bruskotter 2014). As human populations grow, large carnivores often cohabit near human settlements and their conservation is subjected to the capacity of local people to coexist with those animals (Treves and Bruskotter 2014; Blake and Loiselle 2018). South American cougar *Puma concolor concolor* (Linnaeus, 1771) records are abundant in the Ecuadorian Amazon and north coast area, but scarce in the central and southern coast of Ecuador (Hodge and Arbogast 2016). The last records of *Puma concolor* in the Guayas Province date to 1991 retrieved through a rapid assessment in Cerro Blanco Reserve (Registry-Migration.Gbif.Org 2018). The lack of records during this time period could be due to the scarcity of cougars, their elusive behaviour, low natural density, historical persecution by people, extensive home-range, the need for effective monitoring or a combination of such (Hodge and Arbogast 2016; Azevedo et al. 2018). In the case of species that are scarce in numbers and difficult to detect, indirect observations and local knowledge should be considered to perform efficient conservation and management actions (Miotto et al. 2012; Angelici and Rossi 2020). Additionally, management scenarios can be supported with the presence of wild animals and animal traces serve as valuable evidence to aid in the identification of wildlife species (Dudley 2013; Allen et al. 2017; Angelici and Rossi 2020; Petso et al. 2022).

Cycling and, to a lesser extent, the presence of hikers in natural environments, negatively impacts wildlife (McCarthy and Possingham 2007; Newsome and Davies 2009; Procko et al. 2022). In the work of Vera Morales et al. (2021) within the ESPOL territorial limits, erosion and vegetal disturbance produced by visitor's use was stated to be mild or moderate in four itineraries. According to the International Union for the Conservation of Nature, a protected area is "a clearly defined geographical space, recognised, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values" (Dudley 2013). This definition is also recognised by the Technical Guide for the Delegation of the Decentralised State and Autonomous Protected Areas of the National System of Protected Areas of Ecuador (SNAP) (Zárate 2013) whose main objective is to protect wildlife. Additionally, the SNAP technical guidance book includes recreation and sustainable tourism, with consideration given to allowing safe area use and adaptive management, based on ecological criteria (McCarthy and Possingham 2007; Pickering 2010; Procko et al. 2022). Nowadays, several leisure activities such as hiking and bicycling are performed within the ESPOL University territorial limits (Vera Morales et al. 2021).

In this work, we present the results of research that prompted the implementation of adaptive management actions in two areas, BPP and Parcón, considering sensitisation of key actors, wildlife research, citizen-science and collaboration with local authorities.

Methodology

Sensitisation

ESPOL Polytechnic University's (2°08'55.21"S, 79°57'52.20"W) urban area is protected by private security guards who underwent a sensitisation course with an empathetic approach for the conservation of native fauna (Villalba-Briones et al. 2021). First, we identified the private security workforce from ESPOL as a key actor for achieving the conservation objectives due to their high prevalence in the area, surveillance activity and previous collaborations in conservation activities. After receiving sporadic consultations in animal-human conflict cases, a sensitisation course was organised to promote conservation attitudes. The guards completed a six-hour course focused on sensitising them to the well-being of charismatic mammals present in the BPP through empathy-promoting strategies. The course was implemented on 4, 11 and 18 December 2021 at the ESPOL University, Faculty of Life Sciences. A total of 96.6% of the active guards (87/90) attended the course, participant ages ranging from 19 to 63 ($n = 87$; $\bar{X} = 34.07$).

The course involved sharing knowledge on the characteristics of native charismatic mammalian species in the local conservation context, highlighting ecological and ethological perspectives (Fig. 1). The most deeply covered were the following species: ocelots *Leopardus pardalis*, jaguarundis *Puma yaguarundi*, jaguar *Panthera onca*, cougar *Puma concolor*, two-toed sloths *Choloepus hoffmanni*, three-toed sloths *Bradypus variegatus*, ecuadorian capuchin *Cebus aequatorialis* and Ecuadorian howler monkey *Alouatta palliata aequatorialis*; other species such as the white-tailed deer *Mazama americana* and the northern tamandua *Tamandua mexicana* were superficially covered (Tirira 2021). The information-sharing strategy included empathetic approaches towards animals based in ethology, recognising animal emotions and describing their daily dramas, needs and conservation issues (Berenguer 2010; Villalba-Briones et al. 2021). The scientific literature on primates' emotion recognition was essential for identifying animal emotions (Parr and Waller 2006; Gothard et al. 2007; Dal Monte et al. 2014). Emotions covered were joy, surprise, fear and aggression (Parr and Waller 2006; Gothard et al. 2007; Dal Monte et al. 2014).

Apart from general characteristics, the course also promoted the identification of native charismatic species and their traces and linked this information with their daily activities (Zapata-Ríos et al. 2015). At the same time, the learning process was registered through questionnaires before and after every two-hour workshop. Alternatively, before and after the whole course, their preferences towards animals were assessed by following previous studies on animal appreciation. Consequently, participants were asked to mention and draw their favourite animals (three common names and one picture) as part of a simple request (Schlegel and Rupft 2010).

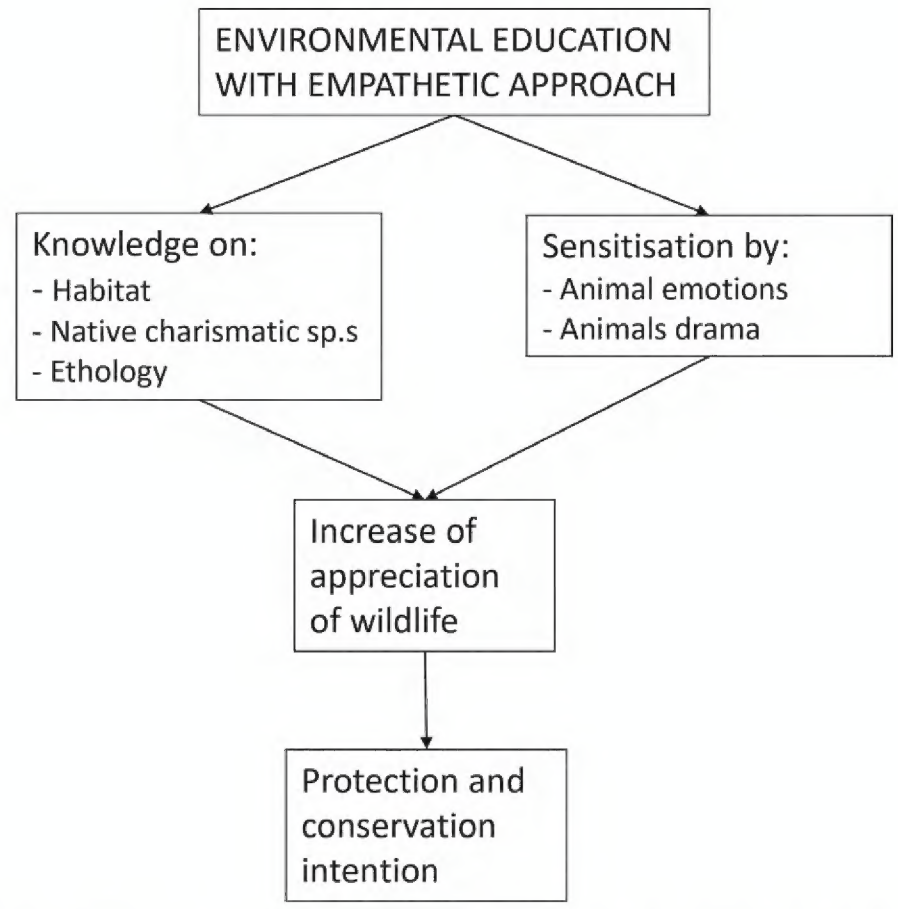

Figure 1. Scheme of the environmental education strategy combining knowledge sharing and empathetic approaches.

Wildlife research

After the sensitisation course, collaboration in management actions were encouraged and guidelines were described. Consequently, in collaboration with local environmental authorities (MAATE- acronym for Ministry of Environment, Water and Ecological Transition in Spanish, and UPMA- acronym for National Police for Protection of Environment Police in Spanish) and the Biodiversity Unit constituted by the Faculty of Life Sciences (ESPOL University), the guards assisted in conservation activities, such as wildlife releases, rescues and security issues during research activities inside ESPOL. Location of the incidences were illustrated in maps designed using ArcGIS pro version 3.1 for posterior analysis.

Statistical analysis

In this study an R-studio platform (RStudio Team 2020) and an R commander package (version 2.7) were used to analyse the data (Fox 2005). The Shapiro-Wilk normality test and Wilcoxon signed-rank test for two samples were applied to analyse evaluation results before and after the course (Woolson 2008; Villalba-Briones et al. 2021). To analyse correlations from datasets that are not bivariate, the normal Spearman's correlation test was used (Myers and Sirois 2006).

Results

Knowledge on the animals

The results of the evaluation on identification capacity of mammals native to the BPP (predators, footprints and primates) showed an increase in all issues after the sensitisation course (Fig. 2A). In predators' identification evaluation (n = 82) results increased to 179.4% (from 32.6 ± 17.9 to a 58.5 ± 29.3% of success) after the sensitisation course. In primates (n = 81), identification values increased by

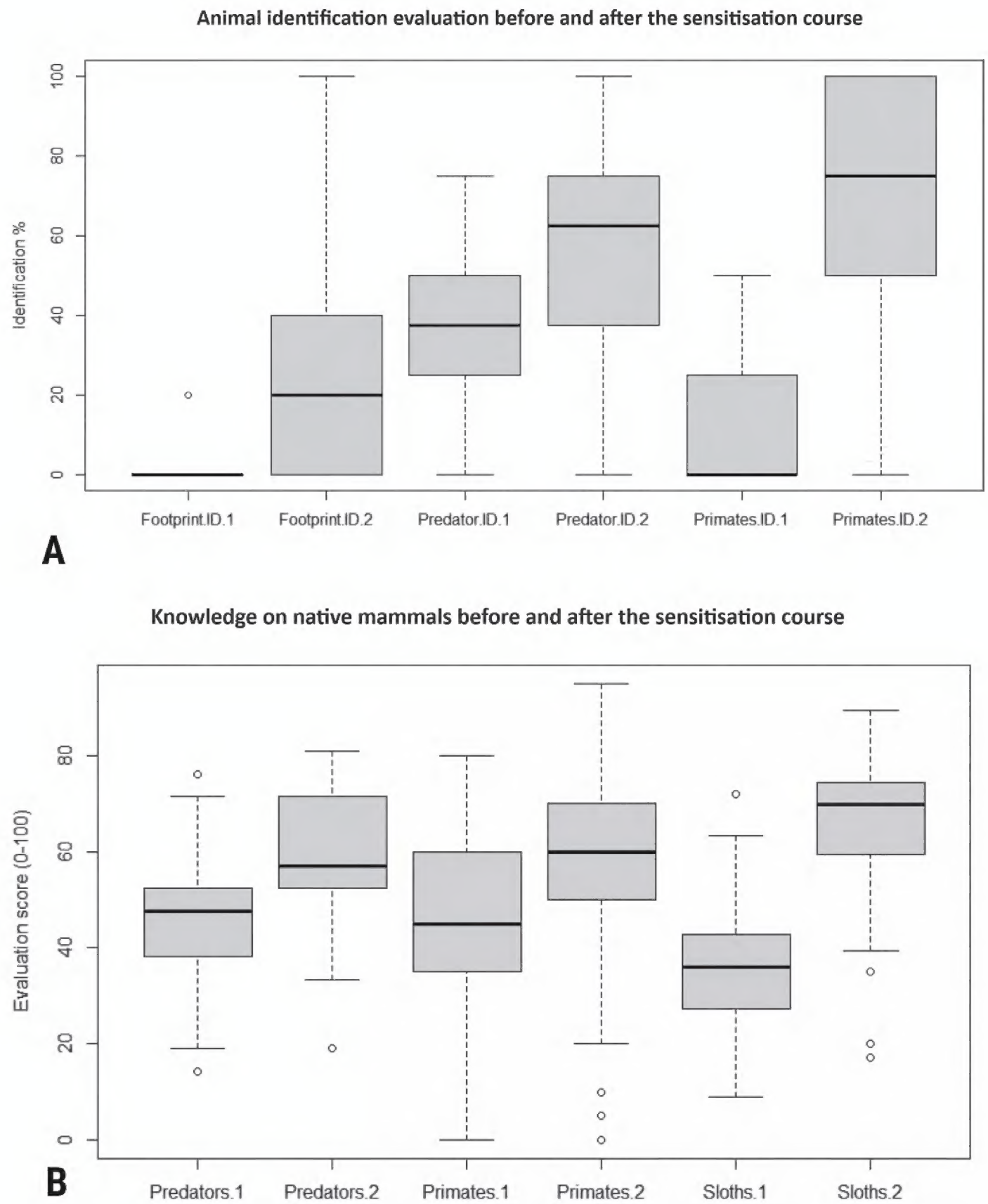

Figure 2. Boxplots showing evaluation result changes before (1) and after (2) the course **A** identification of footprints and predators by images **B** knowledge evaluation on charismatic native fauna from the BPP; predators, primates and sloths.

652.4% (from 10.5 ± 16.7 to 68.5 ± 28.7% of success). The footprint identification success on the test before the sensitisation course was very low, but the guards improved from a 0.5 ± 3.1 to a 27.8 ± 25.7% of success after the course.

The normality of the data was tested and all results, except for the before course results on predators and sloths ($W = 0.97$, p-value = 0.08; $W = 0.98$, p-value = 0.1) showed no normality ($p < 0.05$).

The Wilcoxon test showed that data groups before and after were significantly different in their evaluation results about primates, carnivores and sloths ($V = 341$, p-value = 7.4e-9; $V = 132.5$, p-value = 8.2e-11; $V = 3.5$, p-value = 6.3e-16). Knowledge on native species increased significantly before and after the course amongst guards in all the topics evaluated (primates = 128.73%; predators = 178.43%; sloths = 183.04%) (n = 81; 82; 87, respectively) (Fig. 2B). Consequently, an average of 163.4% improvement in knowledge was achieved, considering all three issues covered.

Sensitisation

Sixty-seven participants successfully filled out the questionnaire about animal preferences (free response; a total of three species) before and after the course and fourteen participants did not change their responses. In the questionnaire before the course, from the species covered, just the cougar and just once, was selected as a favourite species. On the other hand, after the course, all the species were selected as favourites at least once summing to twenty-one mentions in total (cougar and jaguar were the most popular species, with seven and six mentions, respectively).

Wild species were 151.6% times selected after the course and native species 142.9%, which indicates an increase in appreciation of wild and native species (Fig. 3). Dogs (45) and domestic cats (40) remained as the most popular animals after the course.

Regarding to primate emotion interpretation questionnaires, after the course 35.8% of participants improved previous results, 24.7% were worse and 39.5% obtained the same results (n = 81). Overall, the results only reached 108.3% of their initial values. The age and results data did not follow a normal distribution ($p < 0.05$), Spearman's rank analysis showing no correlation between age and the questionnaire results ($p = 0.63$).

Guards' response

From the two reports done three years before the sensitisation course, there were fourteen cases reported by guards during the following 10 months of activity (Table 1). The coordination in human-animal conflict events grew and improved after the sensitisation work, involving the guards, the Biodiversity Unit of the Espol University, Ministry of Environment technicians and Municipal Environmental Police. Apart from the rescues, the Ministry of Environment coordinated four events of liberation involving native two-toed sloths *Choloepus hoffmanni capitalis*, northern tamandua *Tamandua mexicana*, common opossum *Didelphis marsupialis* and green iguana *Iguana iguana* individuals. Private

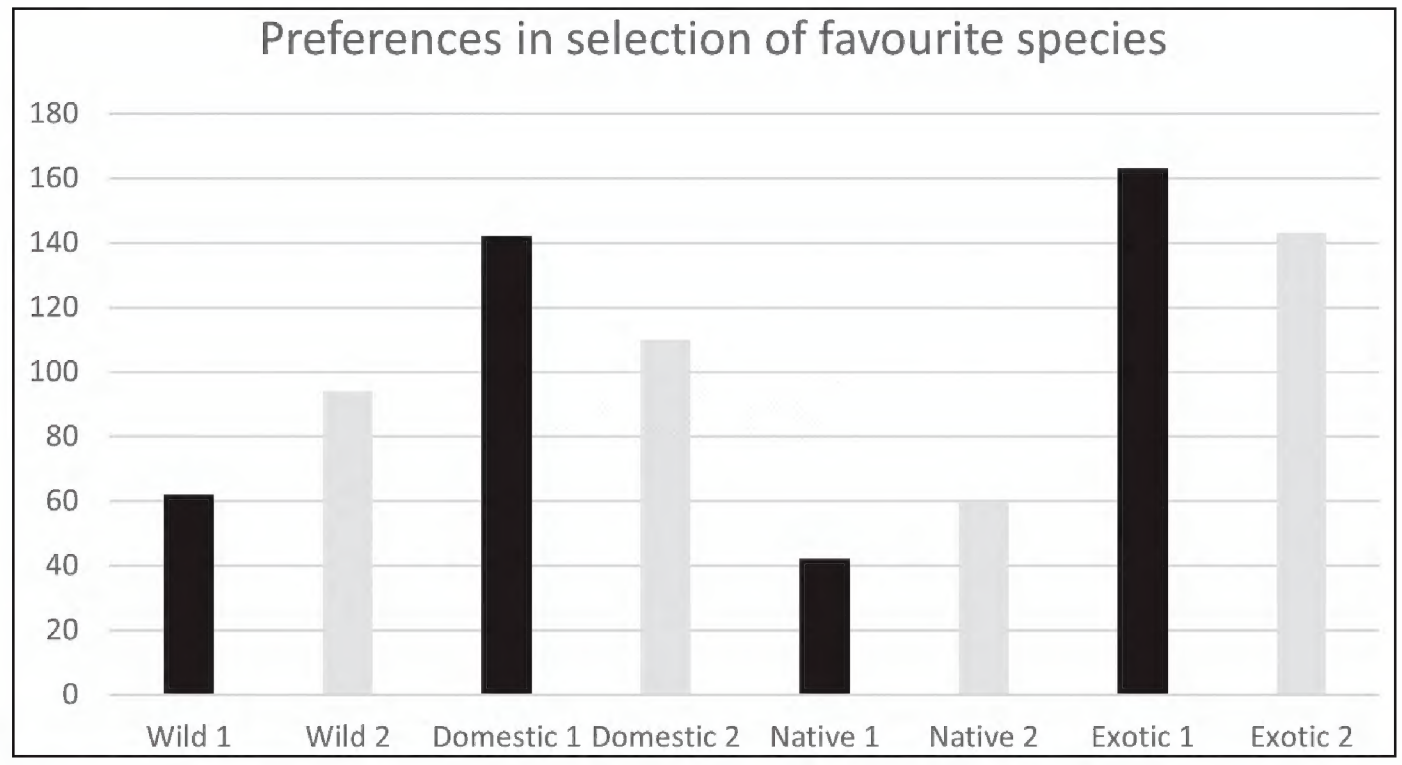

Figure 3. Type of species selected as favourite (three species selection) by the guards before (1) and after (2) the sensitisation course (n = 67).

Table 1. Security guards' reports list on incidence and management actions related to wildlife within ESPOL University territorial limits, Guayaquil, Ecuador.

Year	Month	Species	Type of report	Conflict	Management action
2018	-	*Tamandua mexicana*	Possible rescue	Road interference	Translocation to another forest area
2019	-	*Choloepus hoffmanni*	Possible rescue	Road interference	Follow-up to forest patch
2022	February	*Choloepus hoffmanni*	Possible rescue	Contact with power line	Translocation to another forest area
	March	*Choloepus hoffmanni*	Possible rescue	Road interference	Follow-up to forest patch
	June	*Tamandua mexicana* with a juvenile	Possible rescue	Road interference	Follow-up to forest patch
	July	*Choloepus hoffmanni*	Rescue	Illegal hunting activity	Transport to a rehabilitation centre and subsequent release after treatment
	August	*Boa constrictor*	Rescue	Road interference	Translocation to another forest area
	August	*Sciurus stramineus*	Reported dead	Traffic collision	Safe disposal of the corpse
	August	*Tamandua mexicana*	Possible rescue	Road interference	Follow-up to forest patch
	September	*Tamandua mexicana*	Possible rescue	Road interference	Follow-up to forest patch
	October	*Choloepus hoffmanni*	Possible rescue	Road interference	Translocation to another fore
	October	*Tamandua mexicana*	Reported dead	Possible mountain bike collision	Safe disposal of the corpse
	October	*Eira barbara*	Presence mentioned	None	None
	October	*Mazama americana*	Presence mentioned	None	None
	October	*Sciurus stramineus*	Possible rescue	Road interference	Follow-up to forest patch
	November	*Didelphis marsupialis*	Reported dead and rescue	Human conflict	Safe disposal of the corpse and Ministry of Environment technicians rescue of juveniles

security guards of the ESPOL guided the technicians in all cases, under the recommendations of the Biodiversity Unit of the Life Sciences Faculty.

Most of the detections of wild fauna (11/16) were performed in areas close to roads and in urbanised areas from the ESPOL University (Fig. 4). Real-time communication or researchers' personal guidance and action in situ were implemented during 14 procedures conducted after the sensitisation course. In total (n = 16), three translocations, two transportations to the rehabilitation centre (MAATE), six follow-ups, two presence communication and three corpse disposals were performed. In addition, it is important to mention that most communications were done due to animals being at risk of interfering with traffic on roads inside the campus (10/16). Additionally, we report a verified case of hunting on a two-toed sloth *Choloepus hoffmanni capitalis* (Table 1). The animal was abandoned by hunters after hikers reported the two men with machetes carrying a two-toed sloth to the ESPOL University's private security guards. The animal had three deep cuts in the head area, but after treatment and rehabilitation at the Mansion Mascota veterinary clinic, the individual was released and monitored in the forest.

Field research

Field research related to guards' activity in collaboration with the university researchers revealed two areas with the presence of large to medium-sized species from the Carnivora order. Vocalisations (Fig. 5), urine markings, interactions, predation signs (Fig. 6C), resting place (Fig. 6A), footprints (Fig. 6B, C) and direct observations of animals were registered in two areas of ESPOL University (Fig. 4).

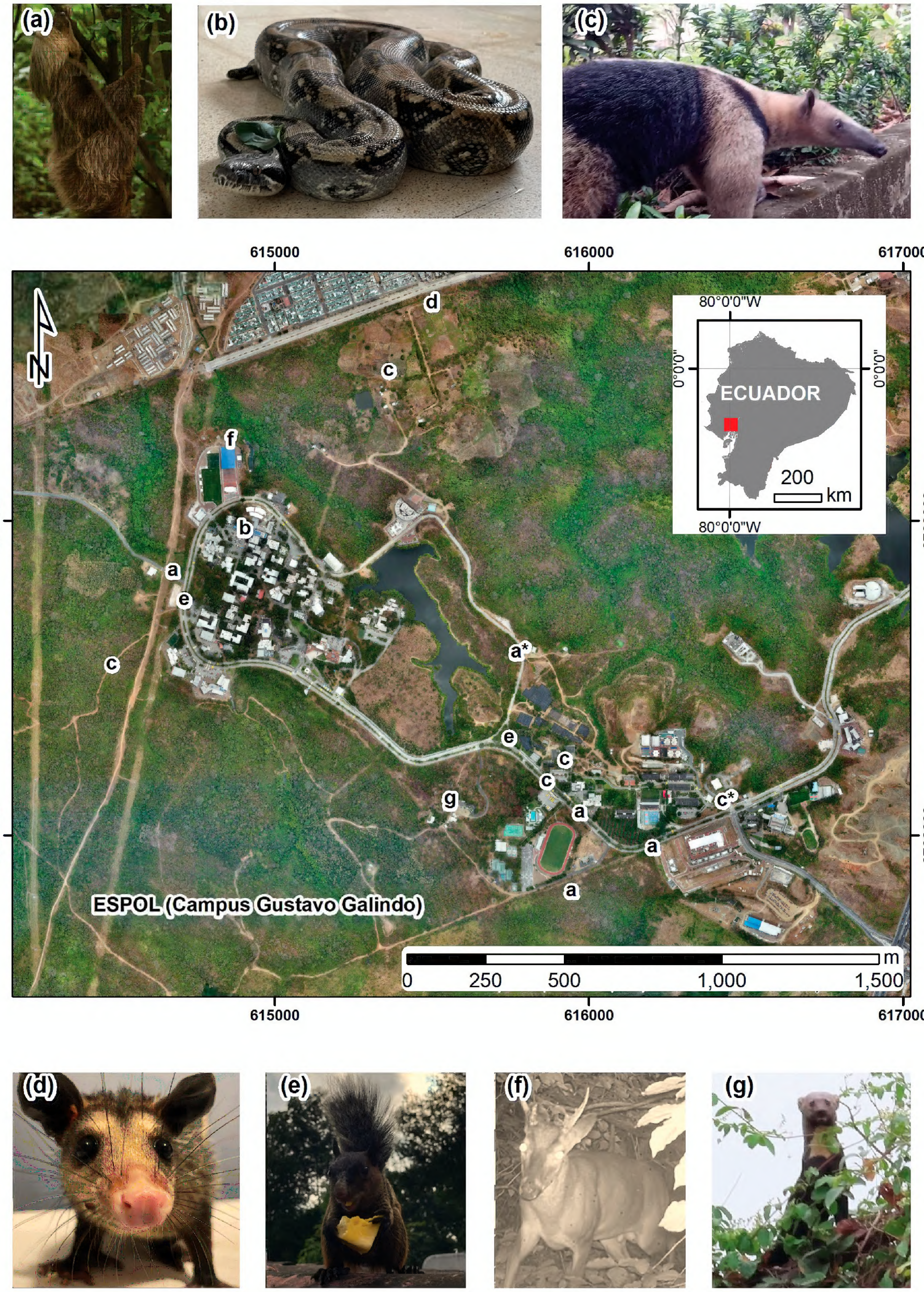

Figure 4. Map showing the presence of fauna based on reports from guards before (*) and after the training curse of the ESPOL private guards **A** *Choloepus hoffmanni capitalis* **B** *Boa constrictor* **C** *Tamandua mexicana* **D** *Didelphis marsupialis* **E** *Sciurus stramineus* **F** *Mazama americana* **G** *Eira barbara*. Authors: Daniel Garces and Ricardo Villalba-Briones. Photographic source: R. Villalba-Briones (ESPOL Campus Gustavo Galindo) (**A, C, F**), Rodolfo Gil (Mansión Mascota) (**B, D, E**), Roger Valencia (Guayaquil) (**G**).

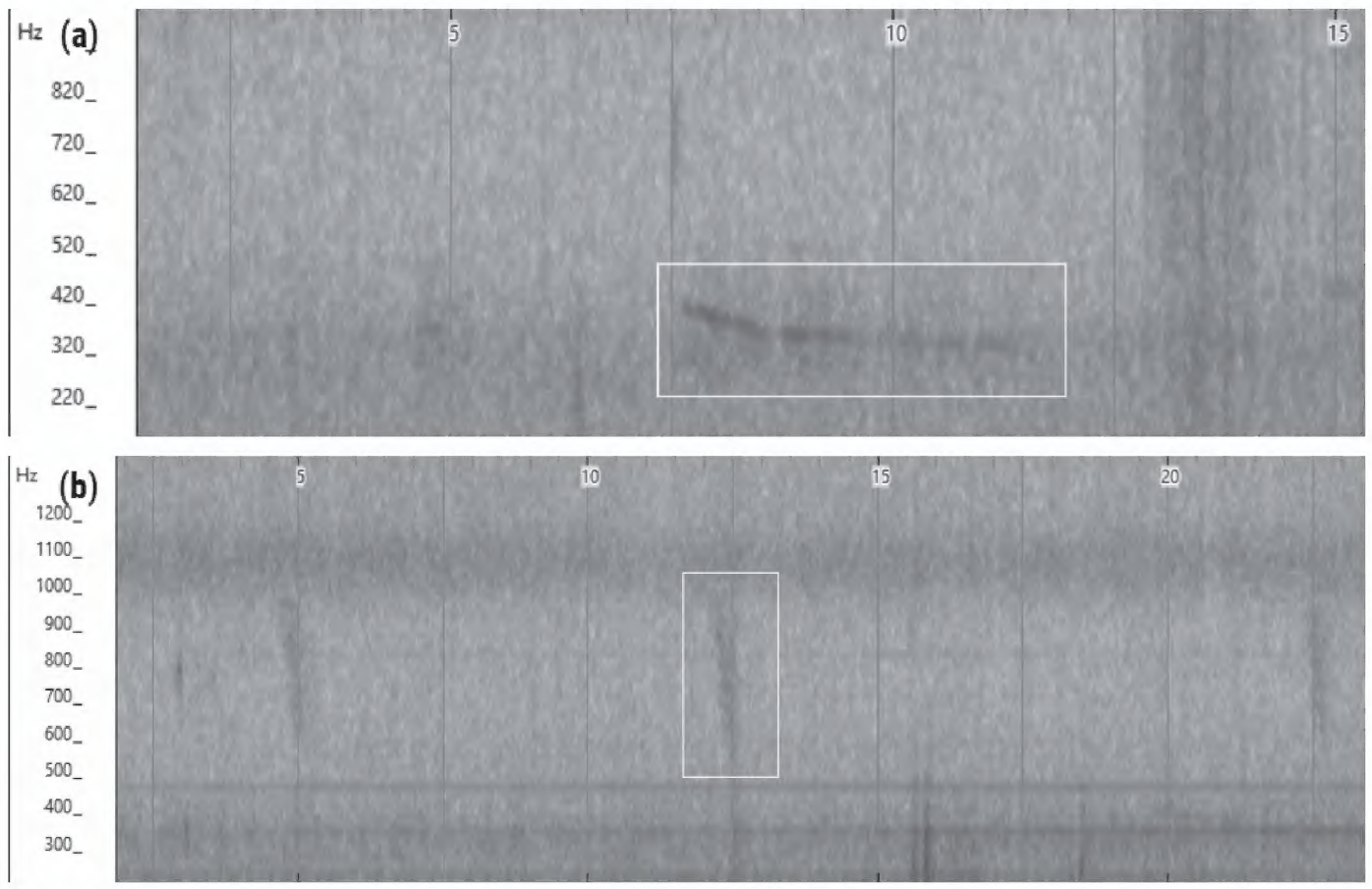

Figure 5. Audiograms of two types of vocalisations presumably of *Puma concolor* recorded in Prosperina Protective Forest, Ecuadorian coast, indicating frequencies and time-lapse **A** V1; 3.8 second maintained "yowl" call **B** V2: three consecutive short "ouch" calls.

Parcón area

After a guard's guidance heading to a suspected felid footprint (Fig. 6B) and, following a fauna path at 15 m distance, abundant and scattered pigeon feathers were recorded as a sign of a predatory activity. Other footprints were found three metres from the feather bulk in the riverine mud of the lake in the Parcón area. The size and shape coincide with the characteristics of tayra *Eira barbara* footprint with a 6 cm wide footprint (Fig. 6C) and a hole in the mud with 1.5 cm digit mark. Additionally, holes in the mud were found at a 42 cm distance from frontal to posterior left step and a crawfish head *Procambarus* gen. (Fig. 6D) (Schuster et al. 2015; Riascos et al. 2018) was found at five metre distance suggesting a predation event of a Neotropical otter *Lontra longicaudis* or, more feasibly due to previous records, tayra.

BPP area

During the nocturnal follow-up of a released two-toed sloth, a bulk of feathers was found displaced in the same 50 cm diameter ground and urine markings were noted. Two camera traps were placed near the area after slightly clearing it and, after around two hours, two types of predator vocalisations were perceived at approximately 50 m distance (Fig. 5). Due to the persistence and vicinity, the ongoing night monitoring concluded and the area was abandoned. The survey continued for three more days in daylight conditions and a resting place was detected at 44 m from the camp. This resting place was in a low-visibility and densely-vegetated area. The ground used to rest showed transformed terrain of approximately two metre diameter and protection of lower tree branches. The characteristics of the location included a slope, a high density of vegetation up to 1.5 m tall, a dense canopy of bushes and dispersed trees. While exiting the forest, a low guttural felid snarl was heard (but not recorded) at 5–10 m from

Figure 6. Indirect records of predation and resting places inside ESPOL University territorial limits **A** Prosperina Protector Forest resting place of large-size mammal **B** Parcón area *Puma concolor* suspected footprints recorded by the ESPOL guards **C** Parcón area frontal 6 cm *Eira barbara* footprint near lake mud, phalange paw trace 2.5 cm long, 1.2 cm wide **D** crawfish head visible at three metres from a burrowed area on predation activity near a *Eira barbara* footprint. Source: I. Ugalde, R. Villalba-Briones.

the researchers' side and behind dense riverine vegetation in a typical predator-stalking manoeuvre. As a result, the fieldwork in the area ended. Camera traps recorded a *Sylvilagus daulensis* and *Mazama americana*, a male and female, but no felid was recorded. One camera appeared to have fallen from the tree and the fabric band used to attach the camera went missing.

Regarding to recorded vocalisations in the field, first, a series of "yowl" calls were recorded (V1), which then changed into "ouch" calls (V2). An analysis of the V1 call's sound spectrum showed a 3.8 sec of duration and ranged from 430 to 312 Hz with a dominant frequency of around 400 Hz (Fig. 5A). Subsequently, a second type of vocalisation was repeatedly performed by the animal as short, broken calls (V2), with a duration of 0.39; 0.34; 0.28 seconds and between 7 and 11 seconds of interval (Fig. 5B). The frequency of these second types of sound ranged from 637 to 990 Hz, 545 to 1020 Hz and 590 to 996 Hz, respectively.

Adaptive management response

During reported footprint revision, non-regulated itineraries that disrupted the continuity of the forest were registered. At that moment, twenty cycling itineraries had been declared inside the ESPOL limits. Due to the extension of the 570 ha forest, it was considered detrimental for the conservation of large animals of great ecological importance, such as native ungulates and wild cats (Pickering 2010). These animals require large territories and a low degree of disturbance in their habitat to maintain healthy populations (Samia et al. 2015; Procko et al. 2022). For management purposes, a two-hour interactive talk was offered to the leading cyclist association operating in the area. The talk explained protected areas objectives, charismatic and native mammals' ethological examples related to human-wildlife conflicts and international experiences on management. After reasoning on the issues related to impacts on fauna, five declared that itineraries were to be closed. Additionally, two non-declared mountain cycling itineraries were closed and three alternative itineraries were proposed following the fire clearings (Fig. 7). The itineraries that cyclists can enjoy which only cause minor impacts were allowed (McCarthy and Possingham 2007; Pickering 2010).

Based on the information gathered after consulting with groups of interest from the ESPOL University, such as the Sustainability and Biodiversity Unit, the importance of the BPP core area (CA) and Parcón CA were identified and management measures (Fig. 7) were discussed. Consequently, support for signal-

Figure 7. Map of the Gustavo Galindo Campus of ESPOL, showing proposed core areas (CA) for protection and signalling under management criteria, based on wildlife protection and visitors use.

ling designs and production was accepted by the institution. After a three-week adaptive management response time, signalling was implemented across the university area informing visitors about the norms to follow a protective code of conduct towards nature conservation in ESPOL University´s natural areas. Thus, 15 signals informed about the closure of itineraries, the importance of the areas for fauna, traffic slowdown for the safety of wild animals and hunting prohibition. Additionally, the Environmental Ministry's contact number was included for reporting incidences with wild animals or other non-civic types of behaviour towards natural values. Addressing context-based communications inside the campus, visitors can provide information about human-animal conflicts and illegal or non-civic types of behaviour inside natural areas.

Discussion

The sensitisation course improved the willingness to help and positively encouraged guards towards conservation, leading to better communication and a more effective management of the area. By explaining the animals' life and dramas, the listeners can relate not only to their challenges, but also to the animal emotions, fostering an empathetic perspective (Berenguer 2010). In management practice, the readiness to inform about the observations and conflict events allow for a fast reaction, increasing the chances of implementing an efficient response to human-animal conflicts. Knowledge on carnivores' traces and footprints is valuable for recording any faunal activity in the territory, to monitor and assist animals activating established protocols if needed and mitigating possible threats (in the case of vehicular activity).

The COVID-19 pandemic severely limited public access to the area within ESPOL University, resulting in a quieter and more gentle environment for wildlife. Consequently, it is probable that the wildlife has increased the exploratory use of the ESPOL forest and urban areas during the lockdown within the university´s territorial limits, as it has been observed in other countries (Behera et al. 2022; Naseer et al. 2022). On the other hand, there are no sightings without observers and an increase in attention to the environment during lockdown could also be a key to increase sightings (Zellmer et al. 2020; Montgomery et al. 2021). However, in the case of this study, there were no communications from the guards in 2020 and 2021. Additionally, the communication of human-wildlife conflicts and fauna observations during previous periods were merely anecdotal, indicating the role that sensitisation played in increasing human-wildlife conflict communication and subsequent resolutions within the ESPOL University. The private security operated continuously during the pandemic.

Previous works have documented threats, such as low guttural growls, when approaching *Puma concolor* individuals as experienced by the researcher (R. V-B.) (Logan and Sweanor 2001; Sweanor et al. 2005). Logan and Sweanor (2001) also identified a 3–7 second "yowl" vocalisation that fits with the V1 description (Fig. 5A). "Yowls" are mentioned in various works on *Puma concolor* vocalisations (Logan and Sweanor 2001; Galentine and Swift 2007; Macarrão et al. 2012). Similar sound behaviour with main frequencies between 0.3 and 0.4 kHz. are represented in other audiograms, based works on captive *Puma concolor* vocalisations described as low-amplitude moan (Allen et al. 2017), which matches with the record in BPP (see type 3 vocalisation in Potter (2002)).

"Yowls" in *Puma concolor* are interpreted as agonistic vocalisations and can be related to sexual identity, dominance, territory advertisement or sexual calls, as documented by Logan and Sweanor (2001). Similar vocalisations, referred to as "yowl," have also been described in other felids (Tavernier et al. 2020). It is important to note that the camp and the researcher were situated at an estimated 20 and 50 m distance from the calls, respectively, where, two days before, urine markings were noticed (1st and 8th nights) and, in addition, a resting place (Fig. 6A) was found 44 m away from the camp's position. The researcher also recorded the "ouch" call (V2) of *Puma concolor* individuals, which is related to the "yowl" (V1) and is also interpreted as an agonistic call of frustration (Logan and Sweanor 2001). Previous works on *Puma concolor* vocalisations spectrograms showed very similar patterns; the spectrogram of the V2 vocalisation fits the description of an alarm call due to its vertical shape in the Hz vs. time scale and duration (0.3 s) (Fig. 5B) (Allen et al. 2017).The home range of cougars is extensive and includes defined resting places that provide thermoregulatory benefits and mitigation against predation risks (Kusler et al. 2017). The description of the resting site in BPP matches with various descriptions of resting sites used by large mammals in the literature (Maehr et al. 1989; Beier et al. 1995; Adrados et al. 2008; Kusler et al. 2017). The concentration of feathers means that a predator consumed its prey while standing in the same location in a BPP area where no public intervention occurs. It is important to note that these traces of predation could be attributed to the activity of predators, such as Tayra or ocelots that inhabit the area (Zapata-Ríos et al. 2015).

Water bodies are an essential resource for wildlife that gains relevance during the dry season (Beier et al. 1995; Quadros and Monteiro-Filho 2001). Neotropical otters *Lontra longicaudis* eat crustaceans and they predate their burrowed prey locating them by touch (Quadros and Monteiro-Filho 2001). That could explain the holes found in the mud and the crawfish head found at five metres distance in the border of the lake in the Parcón area (Fig. 6D). Alternatively, although crustacean consumption is not a documented item in the diet of Tayra (Grotta-Neto et al. 2021), due to their presence in the area (Fig. 4E; Table 1) and opportunistic behaviour suggest that the crawfish head found could be a predation trace of this species. Further research in the area could clarify the total species list.

Large predator populations are declining around the world under the pressure of anthropogenic impacts, such as direct extirpation or habitat destruction, resulting in severe effects on other species and ecosystem services (Ripple et al. 2014; Treves and Bruskotter 2014). It is not uncommon for relict populations or lonely individuals of large felids to remain undetected after the species is considered depleted from the area or even extinct (Angelici and Rossi 2020). This scenario has been documented in various felid species, such as Bali's tiger *Panthera tigris balica* Linnaeus, 1758) or barbary lions (*Panthera leo leo*, Linnaeus, 1758), which became extinct after several decades without detection (Angelici and Rossi 2020). *Puma concolor* habitat use is influenced by food resources, habitat structure or cover and the intensity of human conflict; however, individuals in contact with human settlements can develop an avoidance behaviour and remain in the area (Samia et al. 2015; Azevedo et al. 2018). Specimens in Guayas Province could constitute a relict population that survives in the connected forests relatively close to urban settlements, which, due to the decrease in human inactivity during COVID-19 pandemic, may have led to an expansion in

their mobility. Other university campuses within the distribution range of *Puma concolor* across the American continent have also reported the presence of the species during the COVID-19 pandemic (Oweis 2021; Picon 2021). It is important to highlight that, according to Angelici and Rossi (2020) the importance of re-emerging or rediscovered populations should acknowledge the following needs: "(1) the need for emergency recovery interventions on the species itself, (2) the need for habitat recovery to enable the species to thrive, (3) the designation of protection of habitats for continued survival of the species and (4) the need for legal re-designation of the species to support its protection" (p. 373).

Cycling is an activity that can have a significant impact on natural areas and can be minimised through appropriate management (Newsome and Davies 2009; Vera Morales et al. 2021). The prolonged use of these areas can disturb wild animals and lead to undesirable encounters for visitors (Pickering 2010; Procko et al. 2022). At the same time, according to the high percentage of reports on animal interference with vehicles recorded in this study, roads have been identified as a primary source of impact on wildlife in the ESPOL University. On the other hand, hunting is a clandestine and often challenging activity to trace, particularly when the aim of hunting is for bushmeat consumption. In this work, we report the first verified case of hunting a *Choloepus hoffmanni* of the Ecuadorian Coast (De la Montaña 2013; Cervera et al. 2016; Torres-Porras et al. 2017). The severity of the wounds affecting the head and body, the machete cuts, reflect no intention to keep the *Choloepus hoffmanni* alive for pet marketing purposes and clearly points at bushmeat consumption. In this scenario, informative signalling about the presence of fauna and the need of vehicular speed reduction was settled to protect animals, drivers and bikers from potential accidents. In addition, illegal hunting prevention signalling can raise awareness and increase reports on this activity, but surveillance cameras in strategic points could also lead to a more active approach against poaching.

Conclusion

Awareness raising activities focused on animal species conservation contribute to the survival of individuals of native species on the ground. We recommend incorporating empathy-based strategies in environmental education and sensitisation activities to encourage conservation attitudes. At the same time, lecturing about local species diversity and techniques to identify them through animal traces promotes a citizen-based wildlife surveillance, helps in establishing protocols and improvement of competences on conservation actions. Interestingly, in our work, these activities resulted in a predominantly static monitoring activity conducted by security guards, which ultimately led to research and management actions.

There are large and medium-sized mammals of interest inhabiting BPP and Parcón forest areas and there is a need for active management implementation. The water systems and forests from the Parcón area and the BPP comprise essential areas for the fauna and should be protected actively. Investment in active surveillance of natural areas is recommended to avoid interferences with the native wildlife, considering the most remarkable areas as Parcón CA and the BPP CA shown in the map (Fig. 7). An established patrol presence should be able to impede the entrance of hikers, bikers and, most importantly, hunters to protected CAs.

In its protected forest condition, the BPP protects the fauna and flora within its boundaries, but other natural areas with high ecological value should also be considered. Constraining disruptive activities is a valuable option when protecting wildlife is prioritised. Therefore, we recommend BPP CA and Parcón CA to be actively protected due to their essential function of providing water and food to wild animals and to maintain management actions, including entry restriction to minimise human presence. We also recommend further non-invasive research using camera traps, collaboration with key stakeholders for implementing protection strategies and expanding surveillance and patrolling efforts.

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Additional information

Conflict of interest

The authors have declared that no competing interests exist.

Ethical statement

No ethical statement was reported.

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Author contributions

Conceptualization: RVB. Data curation: RVB. Formal analysis: DOG, RVB. Funding acquisition: RVB. Investigation: JSM, PMP, RVB. Methodology: DOG, JSM, RVB. Project administration: RVB. Resources: RVB. Software: RVB, DOG. Supervision: JSM, RVB. Validation: DOG, JSM, PMP. Visualization: RVB. Writing – original draft: RVB. Writing – review and editing: JSM, RVB, PMP.

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Data availability

All of the data that support the findings of this study are available in the main text or Supplementary Information.

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Supplementary material 1

ESPOL Universities Ethical Committee aprobation of the study

Author: ESPOL University committee

Data type: pdf

Explanation note: The committee analized the procedures of the sensitization activity and approved the activity data protection and publication of the results in a scientific article.

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Link: https://doi.org/10.3897/neotropical.18.e110615.suppl1

Supplementary material 2

Autorización de recoleccion de especimenes de especies de la diversidad biologica No. 2174

Author: Ministry of Environment of Ecuador

Data type: pdf

Explanation note: Permit to recollect samples and create sinergyc actions with wildlife rehabillitation centres for conservation in the Guayas Province from the environmental guvernamental institution of Ecuador, the MAATE (Ministry of Environment, Water, and Ecologic Transition of Ecuador).

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Link: https://doi.org/10.3897/neotropical.18.e110615.suppl2

Supplementary material 3

Data from questionnaires to asses effectivity of the sensitization course

Author: Ricardo Villalba-Briones

Data type: xlsx

Explanation note: The excel archive shows the results of the guards answering information related to native fauna. The archive show the results before and after the course of senzitization.

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